Topic: N171-059

Magee Technologies, LLC

Verification and Optimization of Advanced Finite Element Modeling Techniques for Complex Submarine Hull Structures
Developing efficient and effective submarine structures requires detailed numerical simulation using finite element model (FEM) analysis. However, disagreements between design agencies on FEM requirements and interpretation have led to delayed schedules and increased costs. Our solution mitigates conflicts by developing guidelines for FEM procedures for complex submarine structures, including large hull penetrations. The procedures are established through an integrated system of analyses and validated by innovative testing. To date, the process has been applied to guidelines for submarine bulkhead taper geometry and correlated to pressure tests. MTech specializes in the design, analysis and certification of complex structures for commercial and DoD customers. Our goal is to transition this technology to ensure reliable, effective development and evaluation of FEM analysis for future submarine programs, such as SSN(X).

Technology Category Alignment:

Modeling and Simulation Technology
Engineered Resilient Systems (ERS)
Ground and Sea Platforms

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SYSCOM: NAVSEA
Contract: N68335-19-C-0119

Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N68335-19-C-0119

Tech Talk: https://www.youtube.com/watch?v=A6nRMUhmPBs

Department of the Navy SBIR/STTR Transition Program

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NAVSEA #2020-0448

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WHO

SYSCOM: NAVSEA

Sponsoring Program: PEO SUBMARINES

Transition Target: Next Generation Attack Submarine-SSN(X)

TPOC:
(202)781-4449

Other transition opportunities: Block updates to existing Submarine Programs, Unmanned Submarines/Special Projects, Commercial Submarine Industry, Navy and Commercial Shipbuilding, Pressure Vessel Design and Analysis

Notes: Mtech has demonstrated the ability to characterize a wide range of the design space for different submarine features, identify critical parameters that drive the response and convey the results through guidelines. The characterization has been validated via scale model hydrostatic testing using Digital Image Correlation(DIC) at the Southwest Research Institute Ocean Simulation Lab.

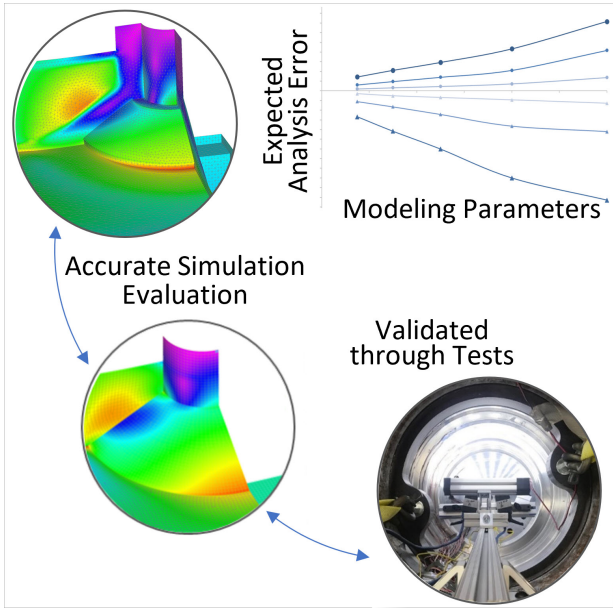

Image courtesy of Magee Technologies, LLC (MTech), 2020

WHAT

Operational Need and Improvement: Current submarine pressure hull structural design methodology involves extensive computational analysis, which requires the development and evaluation of numerous finite element models (FEM). The execution and documentation of these FEM form a significant portion of a submarine program's non-recurring engineering (NRE) budget. Due to analysis and process differences, different stakeholders may disagree about the adequacy and accuracy of a chosen FEM technique. MTech's solution leads to analysis rework reductions, design cost decreases, and schedule acceleration for submarine programs.

Specifications Required: The U.S. Navy requires a design manual, the guidance of which will be validated against physical model tests and will define a set of parameters to be used by shipyard personnel when performing Finite Element Analysis (FEA). The manual must be able to be used to assess the accuracy of FEM of complex submarine structures to ensure that the results accurately reflect the response of a real-world structure. The design resource must be applicable to a range of FEA software and cost-effective to implement.

Technology Developed: MTech has used its modeling and simulation background and the expertise of an experienced submarine architecture consultant (principal in SEAWOLF, COLUMBIA and VIRGINIA Payload Module [VPM] design) to develop an integrated, coherent solution for the development of FEM guidelines for complex submarine geometries. Optimization and statistical tools were leveraged to coordinate and automate thousands of analyses with the resulting trends consolidated into easy-to-use modeling recommendations. The developed guidelines have been validated using innovative, cost-effective pressure tests using reduced-scale models of realistic complex submarine hull geometries.

Warfighter Value: The goal of this work is to reduce the risk of significant schedule delays and the need for rework on submarine hull analyses due to disagreements over FEM approach. This will directly facilitate the delivery of submarine hull systems to the warfighter rapidly and at a better value. The proven methods in developing the guidance in turn will foster confidence in the quality of the delivered system. With applications for future platforms as well as for modifications/repairs to existing ones, this project will provide a far-reaching and long-lasting return on the U.S. Navy's investment. The final Guidance Manual will enable quicker and more cost-effective submarine FEM development with proven quality.

WHEN

Contract Number: N68335-19-C-0119 **Ending on:** March 27, 2021

Milestone	Risk Level	Measure of Success	Ending TRL	Date
An assessment of analysis accuracy across modeling and geometry parameters	N/A	Quantifiable identification of influential parameters and demonstration of tools to convey useful trends to an end user.	3	December 2019
Development of the basic Guidance Manual prototype	N/A	Demonstrate form of the Guidance Manual that incorporates baseline guidance and basic user interface.	4	March 2020
Validated analysis guidance developed for baseline submarine study geometry	N/A	Satisfactory assessment of baseline geometry across operational environments, validated through test correlation results.	5	March 2020
Validated analysis guidance developed for advanced submarine study geometry	Med	Demonstrate the application of the guidance development process to complex submarine structures, validated through test correlation.	6	February 2021
If Option exercised, delivery of Guidance Manual prototype with advanced geometry	Med	Demonstrate incorporation of guidance for complex geometry analysis in a user-friendly form.	6	January 2022

HOW

Projected Business Model: MTech plans to continue its support of NAVSEA/PEO SUBMARINES with a Phase III contract that will enable us to apply our methods and tools toward expanding the analysis guidance and then supporting deployment of the Guidance Manual within the NAVSEA and shipyard structural analysis communities. MTech also plans to apply our innovative and cost-effective testing methods to validate the manual's guidance for full-scale test articles. These will be constructed using production-level manufacturing processes and materials in accordance with the original topic solicitation goals.

Company Objectives: MTech seeks to continue to distinguish our firm as a leader in structural simulation, optimization and analysis, building on our success with the projects we have completed for NAVAIR. This Guidance Manual development project opens up new opportunities for MTech to support NAVSEA, in that our company will be an emerging authority on FEM analysis for complex submarine structures. In addition, the techniques developed to reach the goals of this SBIR topic can be applied to the company's structural design and analysis products for our full range of customers.

Potential Commercial Applications: The guidance manual developed for use by NAVSEA is a potential cited reference for future analysis calculation packages developed by shipyards such as General Dynamics-Electric Boat and Huntington Ingalls-Newport News Shipbuilding. MTech sees potential in assisting these manufacturers in efficient integration of the Guidance Manual in their processes; ideally with the early input of their analysis communities. In addition, the findings and processes used in development of the manual may be of interest to shipbuilding and pressure vessel analysis authorities, such as the American Bureau of Shipping(ABS) and the ASME Boiler & Pressure Vessel Code (BPVC). Similar techniques could be applied to guidelines for aircraft FEM development.

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